(12) UK Patent Application (19) GB (11) 2 181 998 (13) A

(43) Application published 7 May 1987

(21) Application No 8619747

(22) Date of filing 13 Aug 1986

(30) Priority data
(31) 8526292 (32) 24 Oct 1985 (33) GB

(51) INT CL⁴
B62D 65/00 29/00

(52) Domestic classification (Edition I):
B7B PC R

(56) Documents cited
None

(58) Field of search
B7B
Selected US specifications from IPC sub-classes B62D B60R

(71) Applicant
Dow Corning Limited

(Incorporated in United Kingdom)

Inveresk House, 1 Aldwych, London WC2R 0HF

(72) Inventor
Gareth Matthew Jones

(74) Agent and/or Address for Service
M Bullows,
Dow Corning Limited, Cardiff Road, Barry, South Glamorgan CF6 7YL

(54) Method of providing a foamed mass in a hollow vehicle section

(57) A foamed mass is provided in a cavity of a hollow section of a vehicle body using a room temperature curable foam forming silicone composition. Flow of the composition as it foams and cures is restricted by a bag. The bag is inserted in the cavity and the composition introduced to the bag in liquid form. The composition is held in the bag and the composition expands therein and the bag is urged into conformity with the shape of the cavity. By this means inhibition of the cure of the silicone composition by materials in the section is prevented, and the composition is held in place until it has cured so that even heightwise disposed sections with open ended cavities may be satisfactorily treated. The bag remains as a sheath for the cured foam and serves to isolate the mass from its environment.

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SPECIFICATION

Method of providing a foamed mass in a cavity

This invention is concerned with a method of providing a foamed mass in a cavity.

In the manufacture of vehicle bodies including a hollow section, for example of metal, it is sometimes desired to include within the hollow section a material intended to contribute sound deadening, flame retardant or other properties. The shape, size and disposition of those cavities within the hollow section into which the material is to be placed may render the use of blocks e.g. of preformed foam inappropriate. In those cases where it is desired to fill a cavity having a complex shape or one of non-uniform cross section on a production line basis it is likely to be appropriate to introduce to the cavity a liquid material which flows to the desired shape and then hardens or cures to provide a suitable filling. In those cases where light weight or sound deadening properties are desired, it is appropriate to employ a material which also foams when introduced to the cavity. For the avoidance of corrosion of metal sections it is desirable to employ as the material a product which does not encourage corrosion of metal sections or other degradation of items within the section, for example wires or sheathed cables, and equally it is desirable to employ as the material a product which is not adversely affected by other materials present within the hollow section for example waxes, drawing oils, wires and sheaths of cables. These and other requirements have restricted the choice of materials which may be employed.

Liquid, foam forming, curable compositions based on silicone materials are available which flow and foam readily at room or sightly elevated temperatures to provide a cured product which is light in weight, and has sound absorbing and heat resistant properties and may also have flame retardant properties. Known compositions generally require several minutes to cure to a self-supporting condition. When these compositions are used within hollow metal sections in contact therewith, the cure may be inhibited due, for example, to the influence of materials within the section upon catalysts used in the composition and so the cure within hollow metal sections may require a significant period. Attempts to use such compositions for filling hollow sections which have significant openings at their lower ends are thus frustrated by flow of composition from the opening before the composition becomes sufficiently cured to be self-supporting. Whilst it is possible to dam the flow in some cases, this is not always conveniently achieved, and also does not remove difficulties associated with inhibition of the cure.

We have now found that a liquid, foam forming, ambient temperature curable, silicone based composition may be filled rapidly into a cavity in a hollow section of a vehicle body without undesirable loss of the fluid from openings in the section, to provide a cured foam filling if there is first inserted into the hollow section a bag which serves to restrict flow of the liquid composition within the hollow section, is capable of being urged into conformity with the surface of the cavity by the composition as it foams and thereafter serves as a sheath for the cured foam.

The invention provides in one of its aspects a method of providing a foamed mass within a cavity in a section of a vehicle body comprising the steps of introducing to the cavity a bag of flexible material and introducing into the bag a liquid, foam forming, curable silicone composition capable of curing to a foamed elastomeric mass at ambient temperatures, the bag and composition being so chosen that the bag is urged into conformity with the shape of the cavity by the composition as it foams.

In a method according to the invention the bag serves to provide a membrane in the cavity to limit flow of the liquid composition, to provide a container for the composition as it is converted to its cured condition to provide a barrier between the foamable composition and any cure inhibiting substances that may be present in the cavity and to provide a membrane or sheath for the cured foam disposed between the composition and the cavity walls. The bag is chosen so that it may have a perimeter not smaller than the perimeter of a cross section of the cavity to be filled and so that it is flexible enough to be spread out and pressed by the expanding foam into conformity with walls of the cavity. The bag may be of a material which is elastic, inelastic or capable of being enlarged under the influence of the foaming composition but should not act to reduce the volume of the foam after the foam has cured to the shape of the cavity. A method according to the invention may be used to fill or partially fill hollow sections of various sizes and dispositions in vehicle bodies and is principally intended for use in the filling or blocking of hollow sections of vehicles for sound deadening purposes and for restriction of ingress of unwanted materials during use of the vehicle. When using a method according to the invention to block a cavity in a widthwise extending hollow section the bag may be selected to restrict outward flow of the composition whilst permitting heightwise expansion of the foaming composition to urge the bag into conformity with the downward facing interior of the cavity. When using a method according to the invention to block a cavity in a heightwise extending hollow section the bag may be selected to restrict downward flow of the composition whilst permitting widthwise expansion of the foaming mass to urge the bag into conformity with the

interior of the cavity.

The mouth of the bag may be closed before the curing reaction is complete, so that the cured foam is totally enclosed by the bag and this may be particularly advantageous in those cases where it is desired to form a short barrier across a hollow section, or to separate the composition from the surroundings. Alternatively, the foamed mass may be permitted to extend beyond the open mouth of the bag, for example in those cases where it is desirable or permissible for the foamed mass to extend from the hollow section. Materials suitable for providing the bag are those which do not deleteriously influence the curable composition, and which are able to provide bag walls which are sufficiently cohesive to hold the foam as it forms and are flexible enough to allow the bag to be opened out by pressure from the foaming mass and pressed into conformity with the cavity. Bags which are impervious to the curable composition are preferred. Suitable materials include flexible plastics materials for example polyethylene and cellophane. Particularly suitable are bags formed from a tubular extrusion of polyethylene about 0.003mm to about 0.015mm thick.

In a method according to the invention, a liquid foam forming, curable silicone composition is used. The composition chosen is one which is curable at ambient temperature i.e. the temperature in the hollow section at the time of installation which may be in the range from about 15°C to about 30°C for example. Materials which require significant application of heat in order to effect cure in an acceptable period of time impose additional limitations on various aspects of the method, including the choice of a suitable heat resistant material for the bag.

Room temperature curable compositions which foam by virtue of *in situ* production of gases during curing are particularly preferred. The curable silicone compositions preferably comprise a polysiloxane having alkylhydrogen-siloxane units and a hydroxylated material so that the composition is curable to form a polysiloxane matrix which is foamed by evolution of hydrogen gas under the influence of a suitable catalyst (for example a tin salt of a carboxylic acid as referred to in G.B. Patent Specification 798 669 or a platinum catalyst as referred to in G.B. Patent Specification 1 522 637) according to the scheme $\equiv SiH + HOQ \rightarrow \equiv SiOQ + H_2$ as is known in the art. For example curable, foam forming silicone compositions are disclosed in G.B. Patent Specifications 798 669, 867 619 and 1 522 637. Hydrogen gas generated during the reaction causes foaming and expansion of the composition as it cures, resulting in an outward pressure from the composition exerted upon the bag. If desired, foaming of the composition and thus the pressure to expand the bag may be augmented for example by use of additional foaming agent, for example compressed air, nitrogen and the liquefied gases known for use in aerosols, including hydrocarbons, for example methane, ethylene, ethane, propane, neopentane and the many fluorinated hydrocarbons for example methyl fluoride, trifluoromethane, monochlorodifluoromethane and dichlorodifluoromethane. The hydroxylated material (QOH) may be an organic material or a silicon compound and preferably comprises two or more hydroxyl groups per molecule in order to provide a suitable elastomeric foam mass. Preferably the hydroxylated material comprises a polysiloxane having silicon-bonded hydroxyl groups. If desired one may also include in the composition a polysiloxane having alkenyl e.g. vinyl groups, which is particularly beneficial if a platinum catalyst is employed for the addition reaction between the alkylhydrogensiloxane and alkenyl groups, due to flame retardant properties conferred by the platinum compound.

Suitable polysiloxanes having alkylhydrogensiloxane units include polymers having units according to the general formula

$$\frac{R_pHSiO_{(3-p)}}{2}$$

in which each R represents a lower alkyl or phenyl group e.g. a methyl group, and p is 1 or 2. The alkylhydrogen polysiloxanes may also comprise units

$$\frac{R_nSiO_{4-n}}{2}$$

in which R is as referred to above and n is 1, 2 or 3. Curing reactions of the preferred compositions are dependant on presence of appropriate quantities of the interactive functionalities and the alkylhydrogen polysiloxane may be selected accordingly. We prefer that each R represents a methyl group. Preferably terminal groups of the alkylhydrogen polysiloxane have the formula $R_3SiO_{\frac{1}{2}}$ where each R represents a methyl group. Suitable alkylhydrogen polysiloxanes include those comprising MeHSiO units with or without the presence of Me_2SiO units and having viscosities of the order of from about 10^{-6} to about 10^{-4} m^2/s more preferably from about 10^{-6} to about 5×10^{-5} m^2/s.

Suitable polysiloxanes having silicon-bonded hydroxyl or alkenyl groups include polymers which

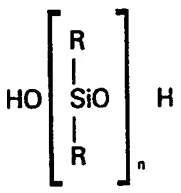
include units according to the general formula

$$R_m(Q)SiO_{\frac{3-m}{2}}$$

in which each Q represents an OH group or an alkenyl group having 2 to 4 carbon atoms inclusive, for example a $-CH=CH_2$ or a $-CH_2-CH=CH_2$ group, each R represents a lower alkyl or phenyl radical e.g. a methyl radical and *m* is 1 or 2. These polysiloxanes also comprise units

$$R_nSiO_{\frac{4-n}{2}}$$

in which R and *n* are as referred to above. These materials are preferably liquids and are chosen so that their functionality is appropriate in relation to the degree of chain extension and cross-linking required during curing of the composition. The polysiloxanes having silicon-bonded hydroxyl groups are preferably silanol terminated polydiorganosiloxanes according to the general formula



in which each R represents a methyl group and *n* has a value such that the polysiloxane has a viscosity of about 5×10^{-4} to 2.5×10^{-2} m^2/s i.e. a number average molecular weight of the order of about 20,000 to about 80,000. Preferred materials have viscosities of the order of about 1.5×10^{3} to about 1.5×10^{2} m^2/s and comprise, per molecule, primarily units according to the general formula R_2SiO and two units according to the general formula $R_2(OH)SiO_{\frac{1}{2}}$. Preferred polysiloxanes having silicon-bonded alkenyl groups include those in which the alkenyl groups provide less than about 5% of the total silicon-bonded organic groups of the polymer. The alkenyl groups may be attached to terminal silicon atoms of the polysiloxane chain or to silicon atoms along the chain or both. Suitable alkenyl polysiloxanes include dimethylvinyl end blocked polysiloxanes for example those having viscosities up to about 8.5×10^{-2} m^2/s and phenylmethylvinyl end blocked polydimethylsiloxanes for example those having viscosities of about 2.5×10^{-4} to about 10^{-2} to about 10^{2} m^2/s. In the preferred materials, each R represents a methyl radical. In preferred compositions according to the invention, the preferred hydroxy and alkenyl functional polysiloxanes thus provide polysiloxane chains of significant length and this is desirable in view of flexibility and elastomeric properties required of the product resulting from curing of the composition. If desired, comparatively low molecular weight, i.e. short chained, organodifunctional polysiloxanes may also be included in the composition. Suitable materials include α,ω, dihydroxy polydimethylsiloxanes having up to twenty five dimethylsiloxane units in the molecular chain.

One may also include in the composition appropriate quantities of higher functional materials as crosslinking agents. Suitable crosslinking agents include materials having three or more functional e.g. hydroxy groups per molecule. Preferred crosslinking agents include an alkoxysilane and/or a condensation product thereof capable of combining with three or more hydroxy polysiloxane molecules with release of the corresponding alcohol of the alkyl radicals, e.g. methyl trimethoxysilane, n-propylorthosilicate and ethyl polysilicate.

Compositions for use in the invention preferably include monofunctional hydroxy silicon compounds effective as chain terminators. Such materials influence the structure of foams formed by use of the composition and their use is highly preferred where predominantly open-celled foams are desired. Suitable monofunctional hydroxy compounds include triorganosilanols and organosiloxanols which may be for example short chain siloxanes having for example up to about 25 siloxane units per molecule and having a terminal or pendant hydroxyl group, or a material of the general formula R_3SiOH where each R may be for example a lower alkyl group e.g. a methyl group or a phenyl group. Examples of such materials include

$HO(CH_3)_2Si(OSi(CH_3)_2)_3CH_3$ (nonamethyltetrasiloxan-1-ol)

$(CH_3)_3Si-O-\underset{\underset{OH}{|}}{\overset{\overset{CH_3}{|}}{Si}}-O-Si(CH_3)_3$ (heptamethyltrisiloxan-2-ol) and

$CH_3(C_6H_5)_2SiOH$ (diphenylmethylsilanol)

Preferably fillers are incorporated in compositions used in the invention. Any desired filler may be employed for example metal oxides, clays, fume silicas, hydrophobic silicas e.g. those prepared by treatment of finely divided silica with organochlorosilanes, organosiloxanes, organosilazanes or alkylsilanols and powdered glass.

Advantages which flow from use of the invention stem primarily from the control of flow of the composition before it has cured to a self supporting condition and from the separation of the composition and hollow section by means of the bag. Thus one may, for example, apply a prescribed quantity of composition to a heightwise extending hollow section without the composition flowing from the section before it cures. One may disregard the possibility of inhibiting the cure of the composition and other deleterious effects which may be caused by materials of or on the hollow section. Equally, one may employ a composition which, in the absence of the bag, might bring about unwanted effects on the hollow section or its other contents. Furthermore one may achieve repetitively uniform filling of cavities in hollow sections with minimal operator attention after introduction of the bag and the liquid composition to the cavity. Further advantages achieved by use of the invention include an improved resistance to moisture transmission via the foam when a moisture impervious bag is used.

A method according to the invention may be employed for the partial or complete filling of cavities in hollow sections of vehicle bodies and is principally of value in the sound deadening of cars and vans which have substantial lengths of open-ended tubular sections. It is of value primarily in those situations where it is important to minimise wastage of material from heightwise extending hollow sections or to ensure satisfactory results without prolonged attention by operatives. Thus it is envisaged as of particular value in the manufacture of vehicles on a production line basis, for example in the treatment of door pillars, "A posts" and the like.

In order that the invention may become more clear, there now follows a description of example method according to the invention and illustrative thereof.

In the example methods the following liquid, foam forming, curable compositions A and B based on silicone materials were used. Compositions A was a two part room temperature curable silicone composition formed by mixing in equal volumes Parts 1 and 2 composed of the following materials.

Material	*Parts by Weight*	
	Part 1	*Part 2*
α,ω hydroxypolydimethylsiloxane viscosity about 1.35×10^{-2} m²/s	22	30
α,ω hydroxypolydimethylsiloxane viscosity about 4.2×10^{-5} m²/s	—	6
Trimethylsiloxy end-blocked polymethyl hydrogensiloxane, viscosity 3×10^{-5} m²/s	—	4
Copolymer of polydimethyl and polymethylhydrogen siloxanes of viscosity 5×10^{-6} m²/s	—	1
Dimethylvinyl end-blocked polydimethylsiloxane of viscosity 4.5×10^{-4} m²/s	17	—
Methylvinyl cyclic polysiloxane	—	.04
Silica filler	8	8
Platinum catalyst compound	0.25	—
Pigment	2.8	—

When mixed, the composition foamed and cured at room temperature to provide a medium density (about 170 to 220 kg/m³) foam having for example good heat resistant, thermal insulation and sound insulation properties.

Composition B was a two part room temperature curable silicone composition formed by mixing 7 parts by weight stannous octoate with a composition comprising

Material	*Parts by Weight*
α,ω, hydroxypolydimethylsiloxane MW about 21,000 (viscosity about 2×10^{-3} m²/s)	100
α,ω, hydroxypolydimethylsiloxane MW about 900 (viscosity about 4.2×10^{-5} m²/s)	10
Diphenylmethylsilanol	10
Trimethylsiloxy endblocked methylhydrogensiloxane, (viscosity about 3×10^{-5} m²/s)	10
Finely divided filler	25
n-propylorthosilicate	4

When mixed, the composition foamed and cured at room temperature to provide a low density (about 120 to 200 kg/m³) foam having for example good sound insulation properties.

Example 1

A bag formed from a tube of circumference 230mm of polyethylene film 0.006mm thick sealed at one end to form a rectangular bag closed at three of its edges and having a width of 115mm was placed in a 250ml beaker (circumference 203mm, radius 32.3mm and height 77mm) with its open mouth at the mouth of the beaker. Composition A was mixed and poured into the bag in the flask. The composition foamed, pressed the bag firmly against the inner wall of the beaker and cured to a medium density in the bag. Observations revealed no evidence of inhibition of the cure due to the polyethylene. Similar results were obtained when composition B was used instead of composition A.

Example 2

A bag formed from a tube of 280mm circumference of polyethylene film 0.006mm thick sealed at one end to form a rectangular bag closed at three of its edges and having a width of 140mm was placed in a rectangular transparent Perspex tube having a cross section of 76.2mm×50.8mm and a height of 200mm. The Perspex tube was open at both ends. The tube was placed with the length of its cavity extending heightwise and the bag was placed in the upper half of the tube with the mouth of the bag adjacent the upper opening of the Perspex tube. Composition A was mixed and poured into the mouth of the bag, sufficient mixed composition being used to ensure the foam produced extended above the mouth of the bag. A lower surface of the bag prevented downward flow of the composition from the bag. The composition foamed, pressing the bag into conformity with the shape of the rectangular tube and cured to trap the bag against the interior walls of the Perspex tube.

Example 3

A Perspex tube as described in Example 2 but having a 10mm diameter hole cut in one wall approximately 100mm from the lower end of the tube was employed. A bag formed from a tube of 330mm circumference of polyethylene film 0.006mm thick sealed at one end to form a rectangular bag closed at three of its edges was inserted in the Perspex tube via the hole. The mouth of the bag was retained on the outside of the Perspex tube. Composition B was mixed and injected through the mouth of the bag to the interior of the bag. The composition foamed, and as it expanded, the bag was urged into conformity with the cavity in the tube and along the tube to an extent permitted by the bag. The composition cured to provide a foam mass trapping the bag against the interior of the tube to effect sealing of the tube.

Example 4

In this Example a cavity in a vertical door pillar of a car body was filled with a foamed mass during manufacture of the car. The door pillar was of conventional construction and presented a hollow section of a generally rectangular shaped cross section of perimeter about 150mm which was open at its base. The hollow section contained a wiring harness comprising pvc coated wires and residue of the usual drawing oils and other contaminants. A bag 200mm long and as used in Example 3 was introduced to the cavity defined by the interior surfaces of the hollow section and exterior surfaces of the wiring harness via a hole in the pillar. The mouth of the bag was retained outside the pillar. Composition B was mixed and injected through the mouth of the bag into the cavity. The composition flowed downward in the bag in the cavity to an extent permitted by the bag and foamed and cured to block the pillar, with the bag trapped by the cured foam against the pillar walls and wiring harness. The mouth of the bag was trimmed off.

CLAIMS

1. A method of providing a foamed mass within a cavity in a section of a vehicle body comprising the steps of introducing to the cavity a bag of flexible material and introducing into the bag a liquid, foam forming, curable silicone composition capable of curing to a foamed elastomeric mass at ambient temperatures, the bag and composition being so chosen that the bag is urged into conformity with the shape of the cavity by the composition as it foams.

2. A method according to Claim 1 wherein the composition comprises a polysiloxane having alkylhydrogensiloxane units, a hydroxylated material and a catalyst.

3. A method according to Claim 2 wherein the hydroxylated material comprises a polysiloxane having silicon-bonded hydroxyl groups.

4. A method according to Claim 3 wherein the catalyst comprises a tin salt of a carboxylic acid.

5. A method according to either one of Claims 2 and 3 wherein the composition also comprises a polysiloxane having silicon-bonded alkenyl groups and the catalyst comprises a platinum compound.

6. A method according to Claim 1 wherein the composition is substantially as hereinbefore described, particularly with reference to composition A or composition B.

7. A method according to any one of the preceding claims wherein the bag is formed from polyethylene film having a thickness from about 0.003mm to 0.015mm.

8. A method according to Claim 1 substantially as hereinbefore described with reference to any one of the examples.

9. A vehicle body having a hollow section containing a foamed composition provided by a method according to any one of the preceding claims.

Printed for Her Majesty's Stationery Office by Burgess & Son (Abingdon) Ltd, Dd 8991685, 1987.
Published at The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.